(12) UK Patent Application (19) GB (11) 2 409 218 (13) A

(43) Date of A Publication 22.06.2005

(21) Application No: 0425956.0

(22) Date of Filing: 01.08.2002

Date Lodged: 25.11.2004

(30) Priority Data:
(31) 60313453 (32) 20.08.2001 (33) US

(62) Divided from Application No
0404796.5 under Section 15(4) of the Patents Act 1977

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(continued on next page)

(51) INT CL[7]:
E21B 43/10 , B21D 39/20

(52) UK CL (Edition X):
E1F FLA
B3J J15

(56) Documents Cited:

GB 2346632 A	**GB 0788150 A**
EP 1235972 A	**EP 1141515 A**
WO 2002/066783 A	**WO 2002/059456 A**
WO 2002/040825 A	**US 5348095 A**
US 4530231 A	

(58) Field of Search:
UK CL (Edition X) **B3J, E1F**
INT CL[7] **B21D, E21B**
Other:

(54) Abstract Title: **An apparatus for radially-expanding a tubular member**

(57) An apparatus for plastically deforming and radially expanding a tubular member which comprises an adjustable expansion device 120 and a means 165 for increasing the size of the adjustable expansion device within an expandable tubular member 175. The adjustable expansion device may be a tubular segmented expansion cone. The means for increasing the size of the segmented expansion cone may be an expansion cone that can be moved relative to the segmented expansion cone.

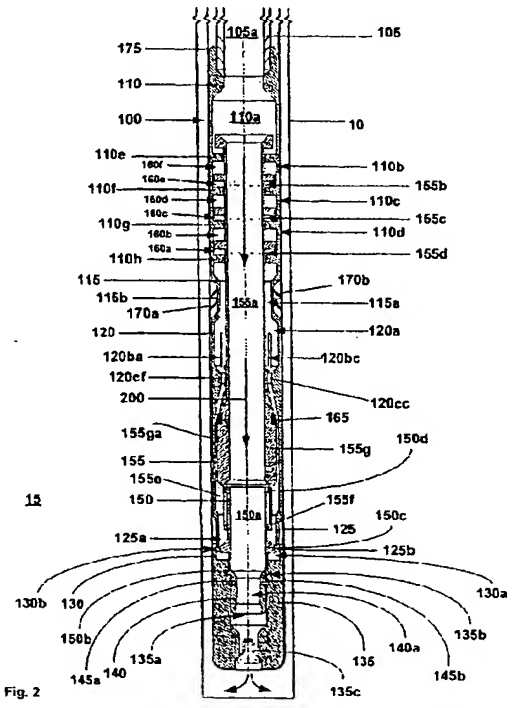

Fig. 2

GB 2 409 218 A

Application No: GB0425956.0 **Examiner:** Nicholas Mole

Claims searched: 1-12 **Date of search:** 13 April 2005

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X,E	1-12	WO 02/59456 A (E2TECH) see esp. figures and page 41 lines 18-26
X	7-12	EP 1235972 A (SHELL) see esp. figure 1
X	7-12	US 4530231 A (MAIN) see esp. figures and abstract
X	7-12	GB 788150 A (BABCOCK & WILCOX) see esp. figures
X,E	1, 3, 7, 9	WO 02/66783 A (ENVENTURE) see esp. figure 17
X	7, 9	EP 1141515 A (PETROLINE) see esp. figure 1
X,P	7, 9	WO 02/40825 A (WEATHERFORD/LAMB) see esp. abstract
X	7, 9	GB 2346632 A (PETROLINE) see esp. abstract
X	7, 9	US 5348095 A (WORRALL) see esp. figures 3 and 4

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

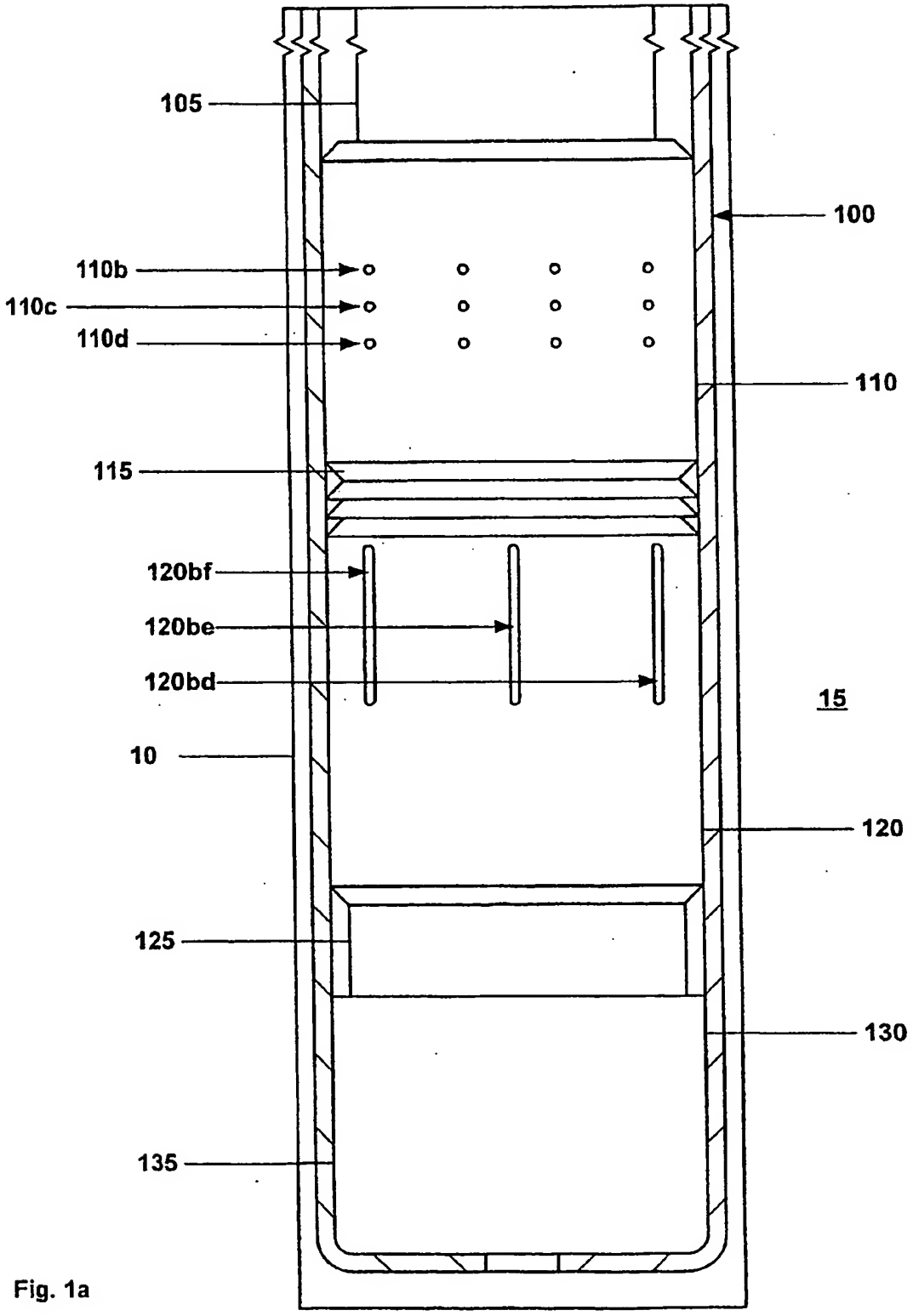
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Fig. 1a

means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member, comprising:

means for positioning a tubular segmented expansion cone within the tubular member;

means for positioning a tubular expansion cone within the tubular member; and

means for displacing the tubular expansion cone relative to the tubular segmented expansion cone.

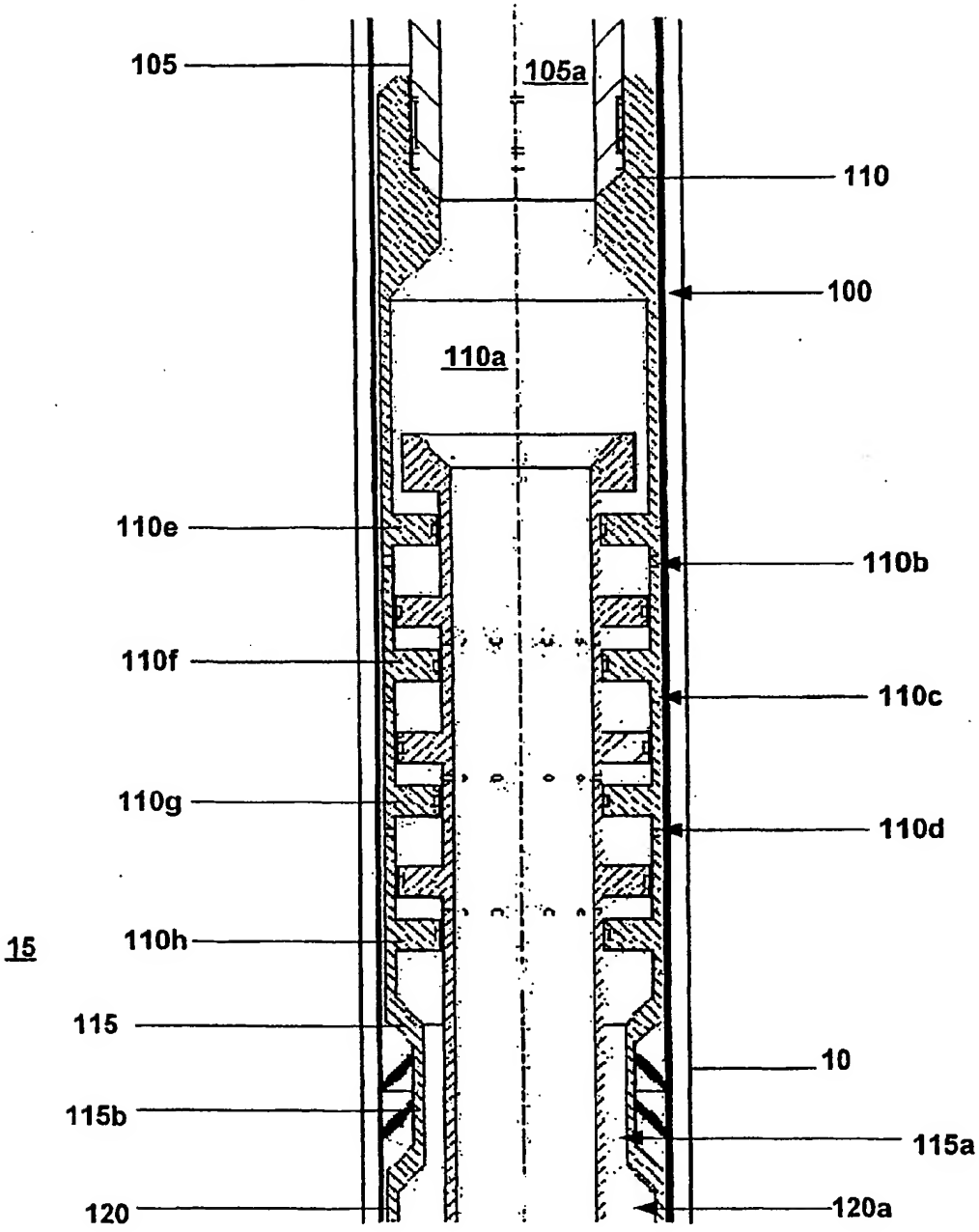
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Fig. 1c

a tubular expansion cone coupled to the second tubular member for radially expanding the adjustable tubular expansion cone;

a shoe releasably coupled to the adjustable tubular expansion cone;

an expandable tubular member coupled to the shoe defining a longitudinal passage for receiving the tubular support member, the adjustable tubular expansion cone, and the actuator; and

one or more sealing members for sealing the interface between the tubular support member and the expandable tubular member.

17. A method of forming a wellbore casing within a wellbore within a subterranean formation, comprising:

positioning an expandable tubular member and an adjustable tubular expansion cone within the wellbore;

increasing the size of the adjustable tubular expansion cone within the expandable tubular member, comprising:

positioning a tubular segmented expansion cone within the expandable tubular member;

positioning a tubular expansion cone within the expandable tubular member; and

displacing the tubular expansion cone relative to the tubular segmented expansion cone; and

plastically deforming and radially expanding the expandable tubular member using the adjustable tubular expansion cone.

18. An apparatus for forming a wellbore casing within a wellbore within a subterranean formation, comprising:

means for positioning an expandable tubular member and an adjustable tubular expansion cone within the wellbore;

means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member, comprising:

means for positioning a tubular segmented expansion cone within the expandable tubular member;

means for positioning a tubular expansion cone within the expandable tubular member; and

means for displacing the tubular expansion cone relative to the tubular segmented expansion cone; and

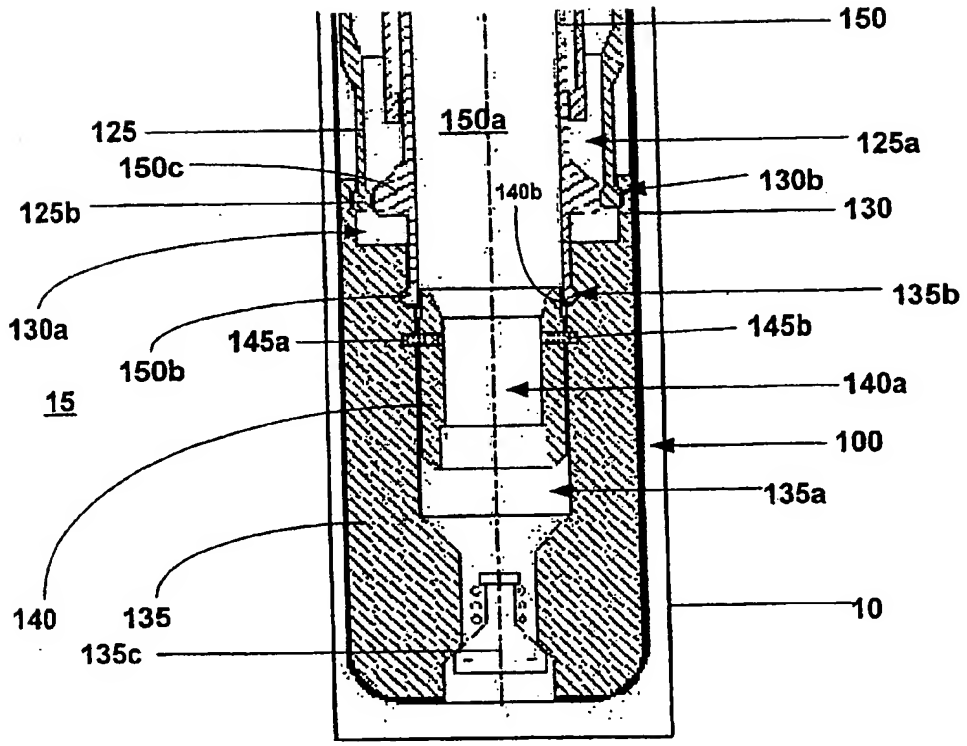
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Fig. 1e

9. The adjustable expansion cone of claim 8, wherein the adjustable tubular expansion cone comprises:

a tubular body defining a plurality of longitudinal slots and comprising a plurality of internal arcuate conical expansion cone segments interleaved among the longitudinal slots.

10. The adjustable expansion cone of claim 8, wherein the actuator comprises:

a first tubular member coupled to the adjustable tubular expansion cone defining a plurality of first radial passages and comprising a plurality of internal flanges interleaved among the first radial passages;

a second tubular member received within the first tubular member defining a plurality of second radial passages interleaved among the first radial passages and comprising a plurality of external flanges interleaved among the first and second radial passages and the internal flanges; and

a tubular expansion cone coupled to the second tubular member for radially expanding the tubular adjustable expansion cone.

11. A method of plastically deforming and radially expanding a tubular member, comprising:

positioning an adjustable tubular expansion cone within the tubular member; and

increasing the size of the adjustable tubular expansion cone within the expandable tubular member.

12. The method of claim 11, wherein increasing the size of the adjustable tubular expansion cone within the tubular member comprises:

positioning a tubular segmented expansion cone within the tubular member;

positioning a tubular expansion cone within the tubular member; and

displacing the tubular expansion cone relative to the tubular segmented expansion cone.

13. An apparatus for plastically deforming and radially expanding a tubular member, comprising:

means for positioning an adjustable tubular expansion cone within the tubular member; and

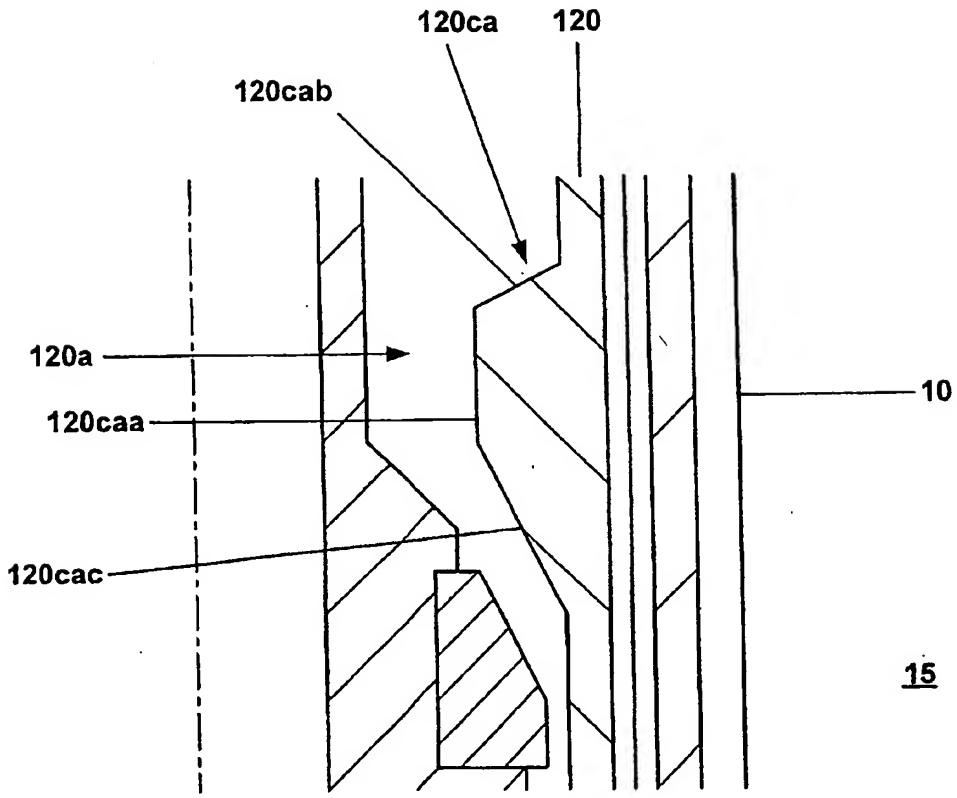

Fig. 1g

1. An apparatus for forming a wellbore casing within a wellbore within a subterranean formation, comprising:

a tubular support member;

an adjustable tubular expansion cone coupled to the tubular support member;

an actuator coupled to the tubular support member for adjusting the size of the adjustable tubular expansion cone;

a shoe releasably coupled to the adjustable tubular expansion cone;

an expandable tubular member coupled to the shoe defining a longitudinal passage for receiving the tubular support member, the adjustable tubular expansion cone, and the actuator; and

one or more sealing members for sealing the interface between the tubular support member and the expandable tubular member.

2. The apparatus of claim 1, wherein the adjustable tubular expansion cone comprises:

a tubular body defining a plurality of longitudinal slots and comprising a plurality of internal arcuate expansion cone segments interleaved among the longitudinal slots.

3. The apparatus of claim 1, wherein the actuator comprises:

a first tubular member coupled to the tubular support member defining a plurality of first radial passage and comprising a plurality of internal flanges interleaved among the first radial passages;

a second tubular member received within the first tubular member defining a plurality of second radial passages interleaved among the first radial passages and comprising a plurality of external flanges interleaved among the first and second radial passages and the internal flanges; and

a tubular expansion cone coupled to the second tubular member for radially expanding the adjustable tubular expansion cone.

4. A method of forming a wellbore casing within a wellbore within a subterranean formation, comprising:

positioning an expandable tubular member and an adjustable tubular expansion cone within the wellbore;

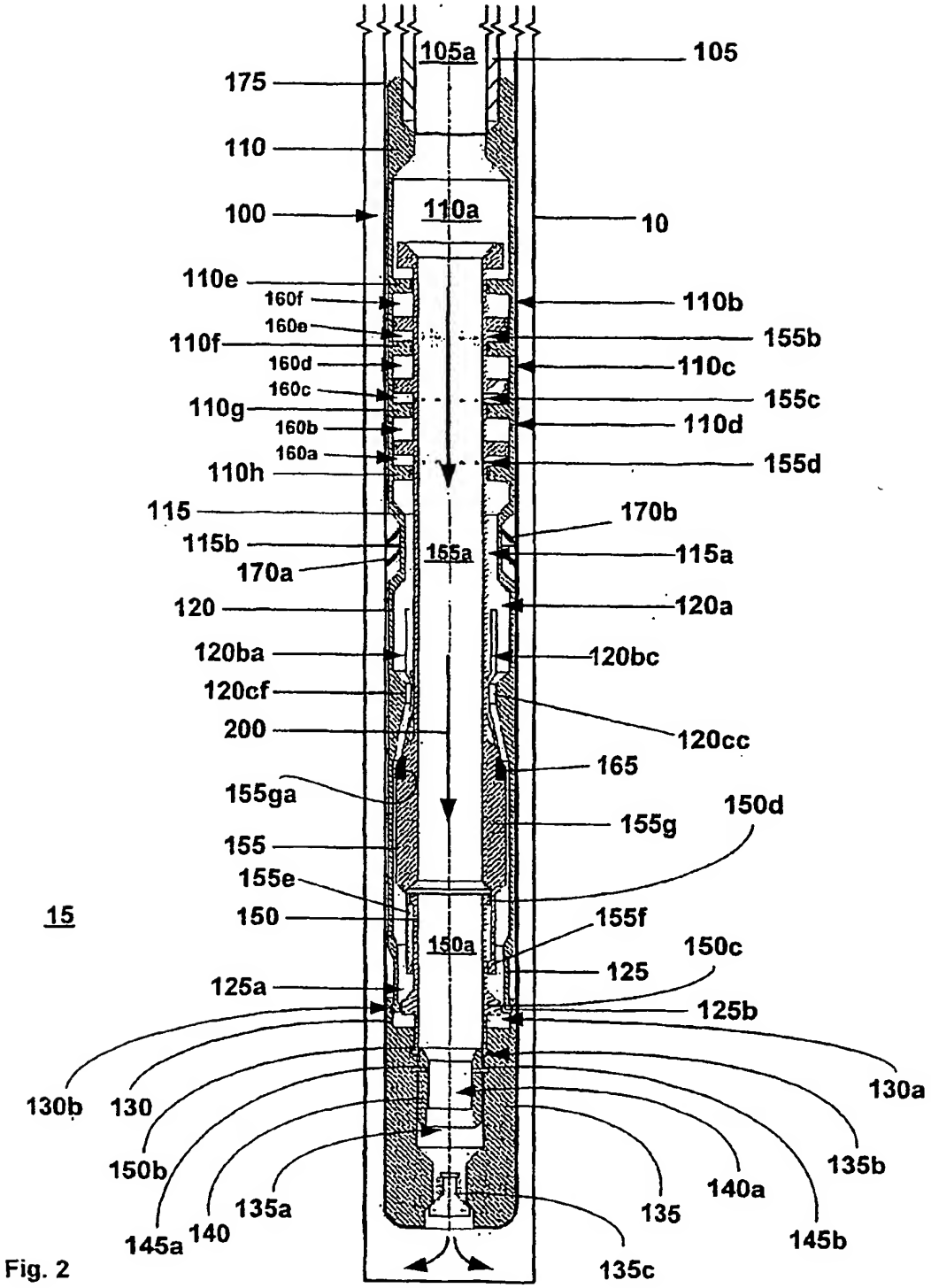
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Fig. 2

adjustable expansion device within the tubular member comprises:

means for positioning a segmented expansion device within the tubular member;

means for positioning an expansion device within the tubular member; and

means for displacing the expansion device relative to the segmented expansion device.

11. A method of plastically deforming and radially expanding a tubular member, comprising:

positioning an adjustable tubular expansion device within the tubular member; and

increasing the size of the adjustable tubular expansion device within the expandable tubular member, comprising:

positioning a tubular segmented expansion device within the tubular member;

positioning an expansion device within the tubular member; and

displacing the expansion device relative to the segmented expansion device.

12. An apparatus for plastically deforming and radially expanding a tubular member, comprising:

means for positioning an adjustable expansion device within the tubular member; and

means for increasing the size of the adjustable expansion device within the expandable tubular member, comprising:

means for positioning a segmented expansion device within the tubular member;

means for positioning an expansion device within the tubular member; and

means for displacing the expansion device relative to the segmented expansion device.

13. A method of radially expanding and plastically deforming a tubular member, comprising:

positioning an adjustable expansion device within the tubular member;

adjusting a size of the adjustable expansion device within the tubular member; and

displacing the adjustable expansion device relative to the tubular member by pulling the adjustable expansion device through the tubular member using fluid pressure.

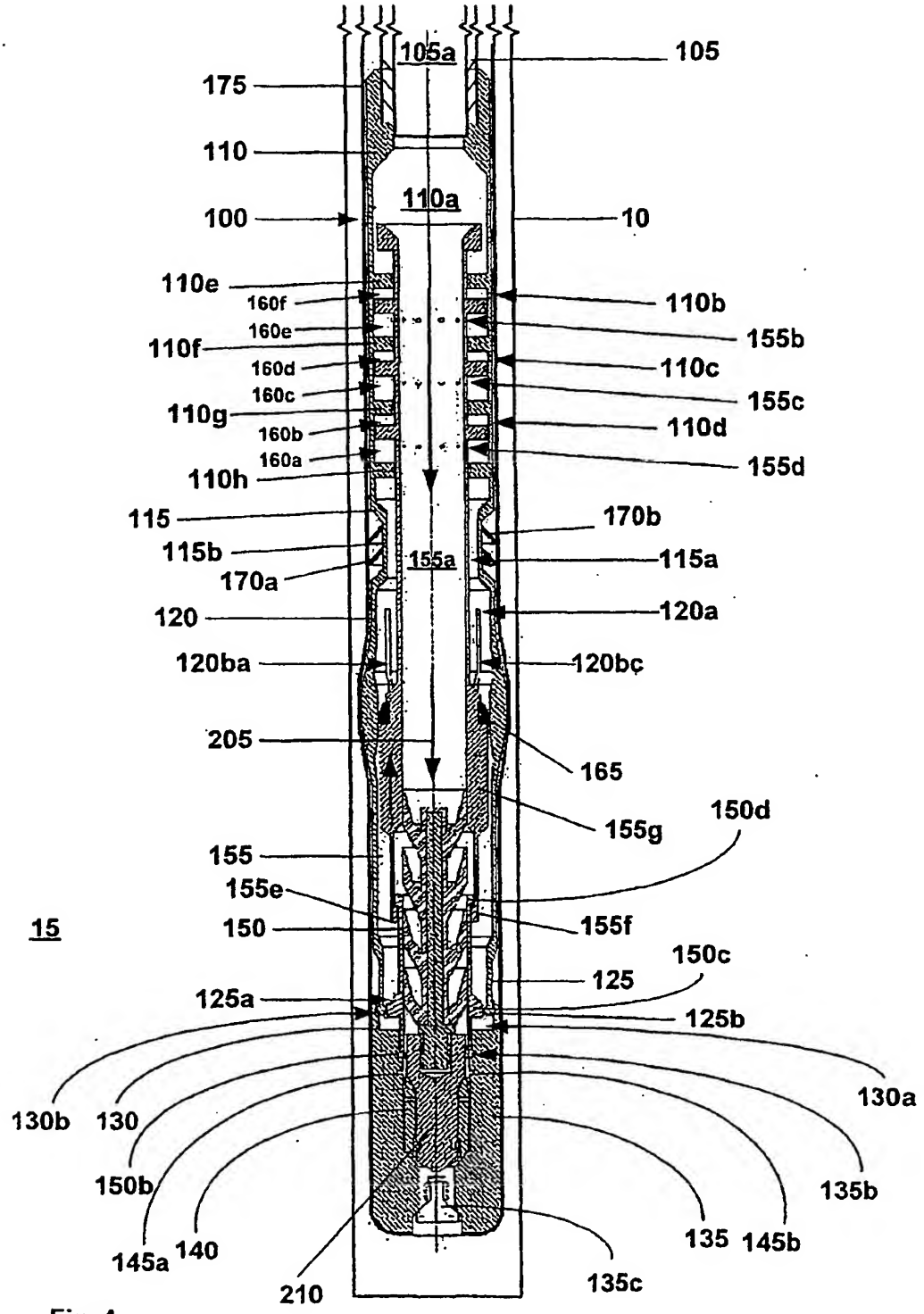
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Fig. 4

Claims

1. A method of plastically deforming and radially expanding a tubular member, comprising:

positioning an adjustable tubular expansion cone within the tubular member; and

increasing the size of the adjustable tubular expansion cone within the expandable tubular member.

2. The method of claim 1, wherein increasing the size of the adjustable tubular expansion cone within the tubular member comprises:

positioning a tubular segmented expansion cone within the tubular member;

positioning a tubular expansion cone within the tubular member; and

displacing the tubular expansion cone relative to the tubular segmented expansion cone.

3. An apparatus for plastically deforming and radially expanding a tubular member, comprising:

means for positioning an adjustable tubular expansion cone within the tubular member; and

means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member.

4. The apparatus of claim 3, wherein the means for increasing the size of the adjustable tubular expansion cone within the tubular member comprises:

means for positioning a tubular segmented expansion cone within the tubular member;

means for positioning a tubular expansion cone within the tubular member; and

means for displacing the tubular expansion cone relative to the tubular segmented expansion cone.

5. A method of plastically deforming and radially expanding a tubular member, comprising:

positioning an adjustable tubular expansion cone within the tubular member; and

increasing the size of the adjustable tubular expansion cone within the expandable tubular member, comprising:

positioning a tubular segmented expansion cone within the tubular member;

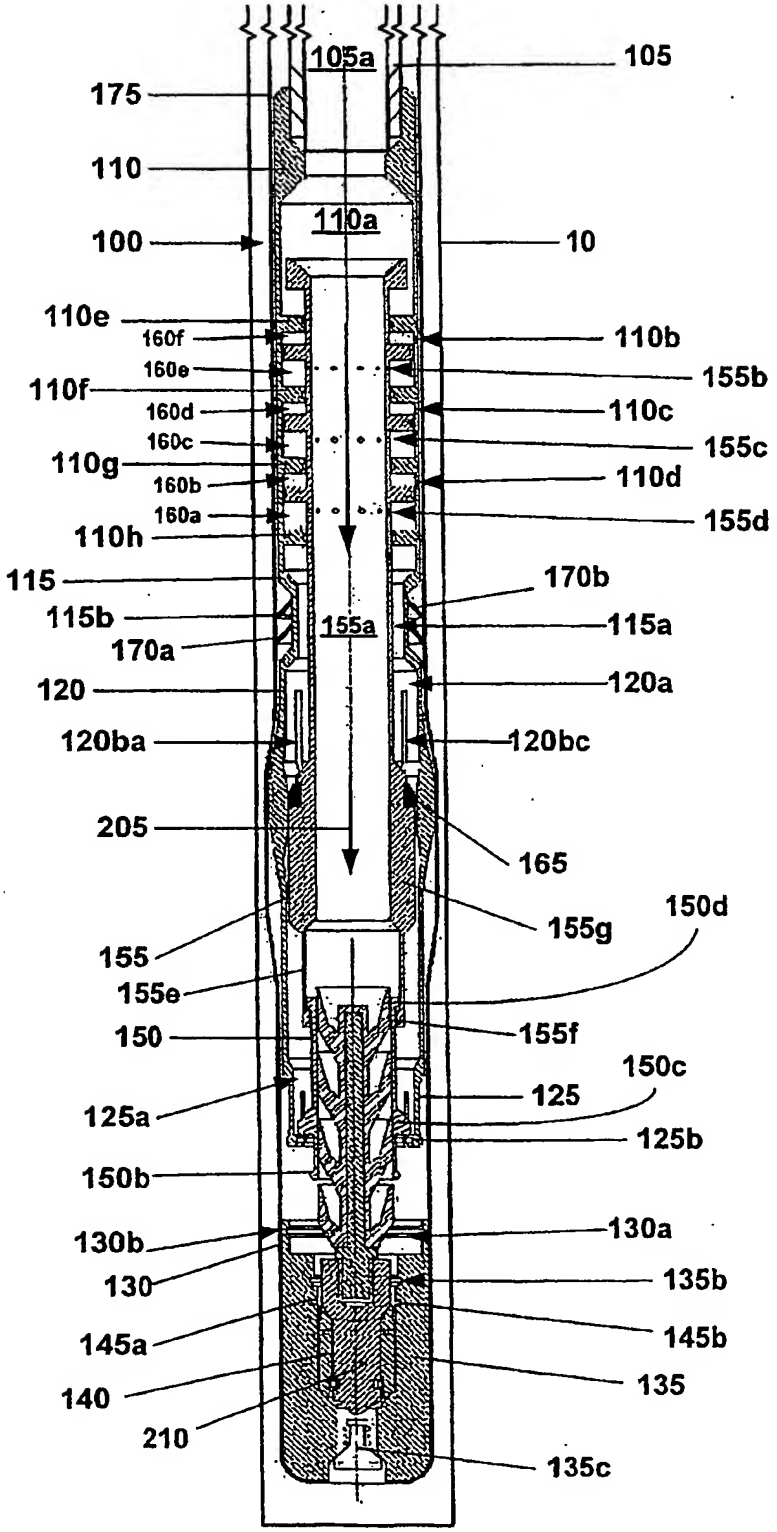
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Fig. 6

expandable tubular member, and displacing the tubular expansion cone relative to the tubular segmented expansion cone.

An apparatus for forming a wellbore casing within a wellbore within a subterranean formation has also been described that includes means for positioning an expandable tubular member and an adjustable tubular expansion cone within the wellbore, means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member, and means for plastically deforming and radially expanding the expandable tubular member using the adjustable tubular expansion cone. In an exemplary embodiment, the means for increasing the size of the adjustable tubular expansion cone within the expandable tubular member includes means for positioning a tubular segmented expansion cone within the expandable tubular member, means for positioning a tubular expansion cone within the expandable tubular member, and means for displacing the tubular expansion cone relative to the tubular segmented expansion cone.

An adjustable expansion cone for plastically deforming and radially expanding a tubular member has also been described that includes an adjustable tubular expansion cone, and an actuator for adjusting the tubular adjustable expansion cone. In an exemplary embodiment, the adjustable tubular expansion cone includes a tubular body defining a plurality of longitudinal slots and comprising a plurality of internal arcuate conical expansion cone segments interleaved among the longitudinal slots. In an exemplary embodiment, the actuator includes a first tubular member coupled to the adjustable tubular expansion cone defining a plurality of first radial passage and comprising a plurality of internal flanges interleaved among the first radial passages, a second tubular member received within the first tubular member defining a plurality of second radial passages interleaved among the first radial passages and comprising a plurality of external flanges interleaved among the first and second radial passages and the internal flanges, and a tubular expansion cone coupled to the second tubular member for radially expanding the tubular adjustable expansion cone.

A method of plastically deforming and radially expanding a tubular member has also been described that includes positioning an adjustable tubular expansion cone within the tubular member, and increasing the size of the adjustable tubular expansion cone within the expandable tubular member. In an exemplary embodiment, increasing the size of the adjustable tubular expansion cone within the tubular member includes positioning a tubular segmented expansion cone within the tubular member, positioning a tubular expansion cone within the tubular member, and displacing the tubular expansion cone relative to the tubular segmented expansion cone.

APPARATUS FOR RADIALLY EXPANDING TUBULAR MEMBERS INCLUDING A SEGMENTED EXPANSION CONE

Background

This application claims the benefit of the earlier filed provisional application Serial No. 60/313,453, filed August 20, 2001, attorney docket no. 25791.59, the disclosure of which is incorporated by reference.

This application is related to the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001; (23) U.S. provisional

expandable tubular member 175. Furthermore, during the continued injection of the fluidic material 205, an annular region 215 between the tubular support member 120 and the expandable tubular member 175 below the sealing cups, 170a and 170b, may be pressurized thereby facilitating the upward axial displacement of the tubular support members 105, 110, 115, and 120, the tubular locking collet 125, the tubular locking sleeve 150, and the tubular tension sleeve 155.

In several alternative embodiments, the design and operation of the apparatus 100 is further provided substantially as disclosed in one or more of the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on

Referring initially to Figs. 1a-1h, an embodiment of an apparatus and method for radially expanding a tubular member will now be described. As illustrated in Figs. 1a-1h, a wellbore 10 is positioned in a subterranean formation 15.

An apparatus 100 for radially expanding a tubular member may then be positioned within the wellbore 10 that includes a tubular support member 105 that defines a passage 105a. An end of the tubular support member 105 is coupled to an end of a tubular support member 110 that defines a passage 110a, a plurality of spaced apart radial passages 110b, 110c, and 110d, and includes a plurality of spaced apart internal flanges 110e, 110f, 110g, and 100h that are interleaved among the radial passages. The spaced apart radial passages 110b, 110c, and 110d may each include a plurality of radial passages distributed around the tubular support member 110 in the circumferential direction. Another end of the tubular support member 110 is coupled to an end of a tubular support member 115 that defines a passage 115a and includes a centrally positioned recessed portion 115b.

An end of a tubular support member 120 is coupled to another end of the tubular support member 115 that defines a passage 120a and a plurality of longitudinal slots 120ba, 120bb, 120bc, 120bd, 120be, and 120bf, and includes a plurality of internal arcuate expansion cone segments 120ca, 120cb, 120cc, 120cd, 120ce, and 120cf. The expansion cone segments, 120ca, 120cb, 120cc, 120cd, 120ce, and 120cf extend inwardly from the tubular support member 120 in the radial direction and include: (a) arcuate cylindrical segment end faces, 120caa, 210cba, 120cca, 120cda, 120cea, and 120cfa, that are substantially parallel to the longitudinal axis of the tubular support member, (b) upper inclined trapezoidal faces, 120cab, 120cbb, 120ccb, 120cdb, 120ceb, and 120cfb, that extend upwardly from the upper ends of the corresponding end faces to the tubular support member, (c) lower inclined trapezoidal faces, 120cac, 120cbc, 120ccc, 120cdc, 120cec, and 120cfc, that extend downwardly from the lower ends of the corresponding end faces to the tubular support member, (d) side trapezoidal faces, 120cad, 120cbd, 120ccd, 120cdd, 120ced, and 120cfd, that extend from the sides of the corresponding end faces to the tubular support member, and (3) side trapezoidal faces, 120cae, 120cbe, 120cce, 120cde, 120cee, and 120cfe, that extend from the other sides of the corresponding end faces to the tubular support member. In an exemplary embodiment, the angle between the upper inclined trapezoidal faces, 120cab, 120cbb, 120ccb, 120cdb, 120ceb, and 120cfb, and the longitudinal direction is greater than the angle between the lower inclined trapezoidal faces, 120cac, 120cbc, 120ccc, 120cdc, 120cec, and 120cfc, and the longitudinal direction, respectively, in order to optimally provide radial expansion of the expansion

and 110h of the tubular support member 110 and the external flanges 155h, 155i, and 155j of the tubular tension sleeve 155 define annular chambers 160a, 160b, 160c, 160d, 160e, and 160f.

A tubular internal expansion cone 165 is received within and coupled to the recessed portion 155ga of the external flange 155g of the tubular tension sleeve 155. Cup seals 170a and 170b are coupled to the exterior of the recessed portion 115b of the tubular support member 115. An end of an expandable tubular member 175 is coupled to the shoe 135 for receiving the tubular support members 105, 110, 115, 120, and the tubular locking collet 125. The annulus between the tubular support member 115 and the expandable tubular member 175 is fluidicly sealed by the cup seals, 170a and 170b.

As illustrated in Figs. 1a-1h, the apparatus 100 is initially positioned within the wellbore 10 within the subterranean formation 15. The wellbore 10 may be vertical, horizontal, or any orientation in between. Furthermore, the wellbore 10 may be a tunnel for receiving a pipeline or a borehole for receiving a structural support. In addition, the wellbore 10 may include a preexisting wellbore casing.

As illustrated in Fig. 2, a hardenable fluidic sealing material 200 may then be injected into the apparatus 100 through the passages 105a, 110a, 155a, 150a, 140a, and 135a out of the float valve 135c into the annulus between the expandable tubular member 175 and the interior surface of the wellbore 10. In this manner, an annular layer of a sealing material may be formed around the expandable tubular member 175. In several alternative embodiments, the annular layer of the fluidic sealing material may be cured before or after radially expanding the expandable tubular member 175.

As illustrated in Fig. 3, a fluidic material 205 may be injected into the apparatus 100 through the passages 105a, 110a, 155a, 150a, 140a, and 135a. A conventional dart 210 may then be seated within the tubular dart seat 140 by introducing the dart into the injected fluidic material 205. Continued injection of the fluidic material 205 may then pressurize the passages 105a, 110a, and 155a thereby increasing the operating pressure in the passages and applying an axial downward force to the dart 210. As a result, the shear pins 145a and 145b may be sheared and the tubular dart seat 140 and the dart 210 may shift downward towards the float valve 135c. As a result, the locking member 150b of the tubular locking sleeve 150 may no longer be locked into the recess 135b of the shoe 135 by the tubular dart seat 140.

As illustrated in Fig. 4, continued injection of the fluidic material 205 may pressurize the passages 105a, 110a, and 155a thereby pressurizing and expanding the annular pressure chambers, 160a, 160c, and 160e. As a result, the tubular tension